Matrix product states-properties and extensions(New Development of Numerical Simulations in Low-Dimensional Quantum Systems: From Density Matrix Renormalization Group to Tensor Network Formulations)

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I will discuss recent studies of the asymptotic critical properties of matrix-product states (MPSs) [1]. Variationally optimized MPSs for the transverse-field Ising model on finite and infinite chains were obtained using $D \times D$ matrices with small $D \in \{2 - 10\}$. For finite chain length N, there are energy minimums for symmetric as well as symmetry-broken states. These energies cross each other at a field value $h_c(N, D)$; thus the transition is first-order. A continuous transition develops as $N \to \infty$. The asymptotic critical behavior is then always of mean-field type (the magnetization exponent $\beta = 1/2$), but a window of field strengths where true Ising scaling holds ($\beta = 1/8$) emerges with increasing D. Asymptotic mean-field behavior was also demonstrated for infinite-size 2D tensor-product states (iPEPS) with small tensors. The behaviors should be generic at symmetry-breaking transitions. I will also discuss recent work on using MPSs and certain generalizations in non-standard ways to obtain ground states as well as excitations [2].

References

[1] C. Liu, L. Wang, A. W. Sandvik, Y.-C. Su, and Y.-J. Kao, Symmetry breaking and criticality in tensor-product states, Phys. Rev. B **82**, 060410 (2010).

[2] C. Liu and A. W. Sandvik (in progress).